Saskatchewan
Agriculture
and Food

Final Report

Agriculture Research Branch
Saskatchewan Agriculture and Food

BAST FIBRE MARKET INTELLIGENCE STUDY

19990200

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1.0 INTRODUCTION AND HISTORICAL BACKGROUND:

Modern day bast fibre processing is presently at a critical threshold of technical and commercial market development. The past five years, accelerating even further over the past two years have demonstrated considerable advancement in the commercialization of bast crops across North America. Within in these developments, the oilseed flax growing regions in Saskatchewan, Manitoba, and North Dakota, and to a much lesser extent Alberta holds a unique and advantageous position to attract suitable processors to utilize the oilseed flax residue.

For the past 50 years, the use of bast fibres in various commercial applications has experienced a steady decline - until recently. Starting in Europe ten years ago and moving to North America three years ago, bast fibres are enjoying a renaissance. Bast fibres had lost their prominence due to improved performance, consistency, and stability of supply of synthetic fibers. Over the past 15 years Western European governments have levied relatively very high disposal costs of synthetic materials, including fiberglass. These changes have resulted in the rediscovery and renaissance of bast fibres, primarily flax and to a lesser extent hemp with an even more modest extent from kenaf. Material developers have recently discovered various advantages bast and leaf fibres offer, particularly in automotive nonwovens. These factors have combined to provide a surge in bast fibre applications.

In the automotive nonwovens industry in Europe, as well as North America, it seems that into the mid-term bast fibres will experience moderate growth. Several bast fibre processors are beginning to pursue fibre-reinforcing composite applications. At this early stage it is difficult to predict with certainty how successful these processors will be in this industry. Fundamentally, composite reinforcements technically appear very promising, still technology, marketing, and financial support of these ventures is uncertain and unclear.

1.1 ECONOMIC COMPETITIVENESS OF INDUSTRIAL HEMP RELATIVE TO LINSEED FLAX:

The pursuit and utilization of flax residue into value-added products offers significantly improved economic viability than that found from industrial hemp. Flax is more viable due primarily to greater performance relative to cost. The bast fibre from linseed flax offers generally comparable performance to hemp for most markets, particularly for composite applications, and yet linseed flax straw (as a residue) is much less expensive than hemp.

The core (hurd) from hemp does offer more applications and ultimately a higher value than the core (shives) from flax. Overall, the added value component from hemp warrants only a very modest increase in the value of hemp stalk, perhaps being worth 20%-40% more than linseed flax residue. Nevertheless, at this time, the breath of market and product development from the hemp core is very immature and substantially less developed than those for bast fibres themselves.

If oilseed hemp were to be available at a comparable price for the residue stalk its use and incorporation with linseed flax is recommended. Due to differences in stalk diameter slight modifications to processing equipment would be necessary. Additionally, due to the potential for gradation in performance it is recommended that hemp varieties be processed separately and kept segregated from flax products. In fact until more conclusive testing occurs, it is recommended all varieties and significant variations within a variety of row and seed spacing all be kept segregated from one another in processing. In a more finished product, it may be best to

purposefully blend these different bast fibre varieties to achieve a selected performance characteristic.

Flax is much more readily adjustable both in its throughput and in a shorted time period to commit to growers (as seed need not be committed by the fall, nearly a year prior to harvest). Market studies show only small, niche opportunities, namely textiles and various green specialty products, for applications in which industrial hemp would be the preferred choice of fibre over competing fibres such as linseed flax. Thus, oilseed flax products demonstrate greater market opportunities and competitiveness.

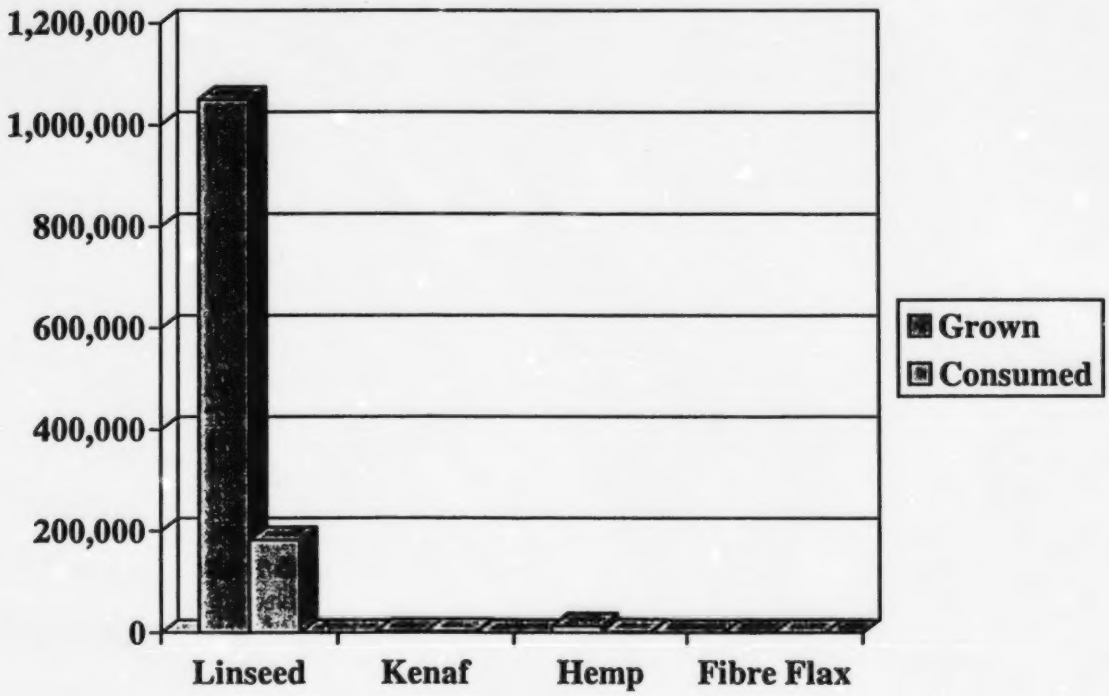
The recent embargo and pursuit of regulatory standards due to discernable THC found in hemp food and oilseed products, from the FDA (Food & Drug Administration) and the DEA (Drug Enforcement Association) both from the United States leaves this industry in a state of great uncertainty. First, FDA and DEA regulations may impose greater restrictions - that may even require zero detectable THC content. Secondly, the duration of these U.S. embargoes has created substantial financial harm to Canadian hemp exporters. Such companies are being economically strangled as their sales are reduced significantly having catastrophic effects upon the cash flow from these businesses.

Fibre varieties that are harvested earlier may produce higher value fibre. Nevertheless, the cost of hemp grown as a fibre crops would be at a severe disadvantage to linseed flax as well as warmer fibre crops such as kenaf, ramie, and jute in terms of cost and ultimately, value. Fibre varieties of hemp are unlikely to be industrially competitive as long as sufficient quantities of linseed flax residue remain. Moreover, the Prairies do not have a climate best suited for the optimal retting of fibre crops, yet the land and climate is well-suited for oilseed crops[1].

[1] Alvin Ulrich of Biolin Research states that with the proper price incentives coupled with "modest cultural and machinery practices" the Prairies can offer adequate retting conditions. As a partial confirmation of this statement, Jim Hill of Hill-Agra Sales states that he has not seen (anywhere) optimal retting techniques employed in North America.

1.2 BAST FIBRE PRODUCTION IN NORTH AMERICA:

The following graphs show the dominance of linseed flax relative to other bast fibre crops. (Data is expressed in hectares)



1.3 ECONOMIC IMPLICATIONS:

For the enlightened, more knowledgeable, bast fibre producer, the Canadian Prairies, Saskatchewan in particular, offer a most competitive supply of bast fibres. For such producers, these more concentrated linseed growing regions offer a gateway for small to moderate scale operations. With sufficient linseed production orchestration to motivate localized concentrations of linseed, production levels of processing could reach 90,000 - 150,000 MT/year of stalk. Ideal processors are those that prefer the lower cost of Prairie linseed flax and the opportunity for greater flexibility in supply. At the same time, such processors should not mind the more diffuse quantities of linseed flax and the lower quality and ultimately value from the core (shive) portions of linseed flax.

More specifically, those processors better suited to utilize the linseed resource should have lower to moderate sized capacities. As annual throughput of stalk increases to 60,000 metric tonnes the additional transportation costs begin to seriously impact the viability of a Prairie linseed location. Such costs become much less competitive as production requirements reach 90,000 - 150,000 MT unless transportation costs are reduced. One obvious way to increase this is for a processor to provide sufficient financial incentives to a substantial portion of growers located near the processing facility to grow flax regularly. (Nevertheless, due to moisture depletion and disease

potential, flax should only be grown once every three to five years, creating inherent limitations through this need for longer periods between allowable plantings.)

Bast processors preferring linseed flax over low cost bast fibre crops, such as kenaf, ramie, or jute, should include those that are less interested in the use of the core (shive or hurd) portions of bast stems. Overall, many bast crop processors may prefer to avoid the additional complexity and challenges that arise from the need to find higher value markets for the core portion. With linseed flax, the core is markedly lower in value than other low cost bast fibre crops, such as kenaf, ramie, or jute. It is likely composite fillers is the preferred (highest value) use for the flax core (shives). In some testing Washington State materials researcher indicated flax shive has a better aspect ratio than wood flour, as wood flour's aspect ratio averages 1:8, while flax shive averaged 1:11. Provided this is true, flax shive, when properly refined, has the potential to command a price to exceed market prices for wood flour by 15% to 40%.

Although challenging from a marketing and aesthetic perspective, it is best from a technical and economic standpoint to try to convince customers to accept a "pre-formulated blend" containing the maximum usable core (shive), likely 20%-35%, as a filler, and the difference being the bast fibre reinforcement. Under these conditions compounders with obtain the maximum allowable less expensive filler, the core (shive), while at the same time allowing the bast processor to use a simple, less expensive decortication process. In light of these preceding dynamics, coupled with the highest likely value of the core (shive) expected to be composite reinforcements and associated fillers, BioComposite Solutions believes the edge is given to composite reinforcement over all other known market applications.

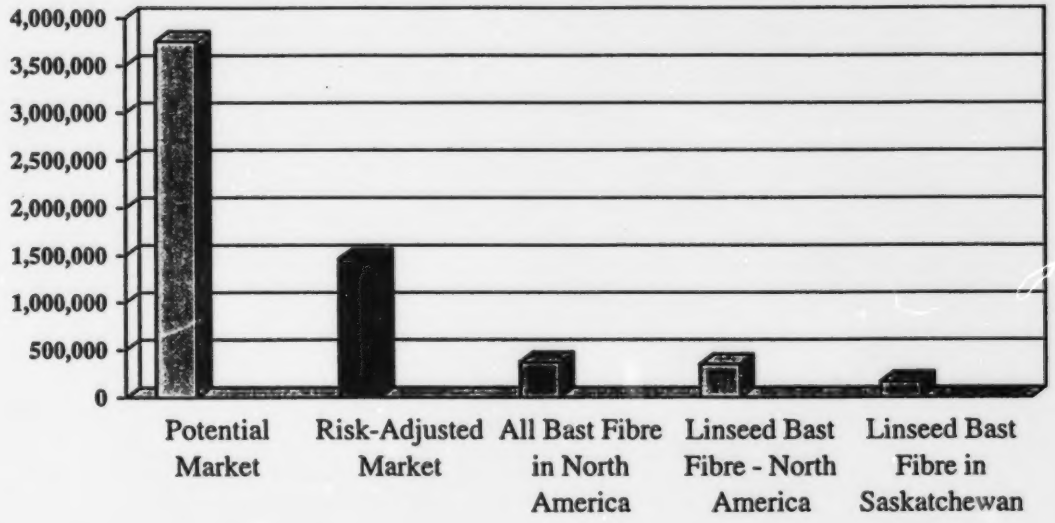
Through numerous interviews, research, and analysis BioComposite Solutions believes that outstanding mid-term potential exist for bast stalk materials, particularly from the bast fibres. Within this development, oilseed flax residues are arguably the best place to first pursue as the cost is the lowest, yet the quality for nearly all potential markets except probably apparel from linseed flax is adequate. Oilseed flax residues from the Upper Great Plains and particularly the Canadian Prairies, when sufficiently concentrated, offer the lowest cost adequate quality bast fibre. For startup developers this source provides sufficient quantities for most production requirements, and as a residue is available for the lowest possible cost.

In the longer term as market development proceeds, semi-tropical and tropical bast fibre crops having much higher yields ranging from 12 to over 26 metric tons of stalk/hectare/season (i.e. year) offer good opportunity to provide significantly larger fibre markets. Moreover, the high yields coupled with the ability for more regular rotation, every two to three years as opposed to the three or more years common with flax will effectively reduce transportation costs to a central processing facility. Baled fieldside, the leading candidates for bast fibre production, kenaf, ramie, and jute presently cost approximately US $ 100-132/MT of stalk field dried. Under more intense agronomic development these field dried stalk costs can be brought down to $ 66-84/MT.

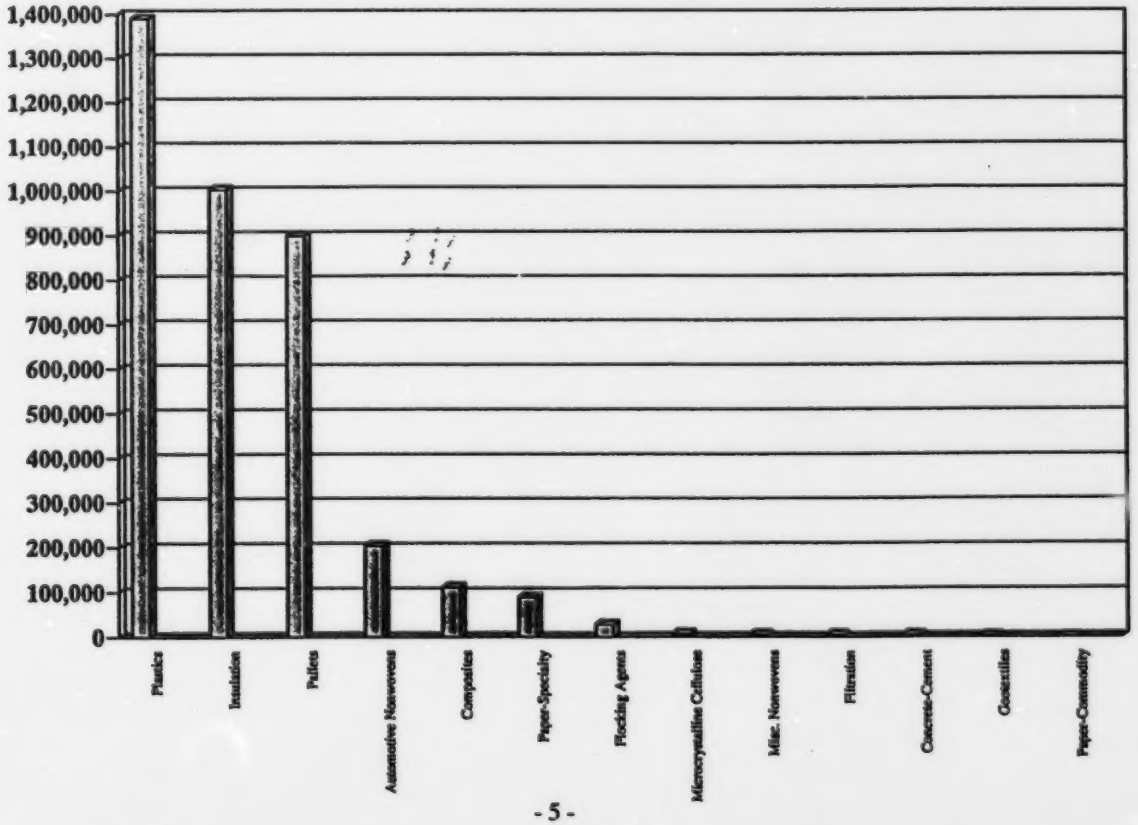
With strong levels of capitalization, market and technical developments very large markets for bast fibre crops can be developed. Nonwoven products, including insulation, offer the global potential for US $4 - 12 billion in sales. Fibre reinforcements in thermoplastics could exceed US $2 billion. Using proprietary technology building materials markets could reach over US $1.0 billion, and at lower margins and extensive substitution for wood (should environmental regulation change significantly) market penetration in building materials could exceed US $ 20 billion. Additional, probably smaller and less mature, opportunities exist for the core portion from bast fibre crops. Leading non-flax bast fibre crops offer the greater potential for these core markets.

2.0 MARKET INTELLIGENCE AND INFORMATION:

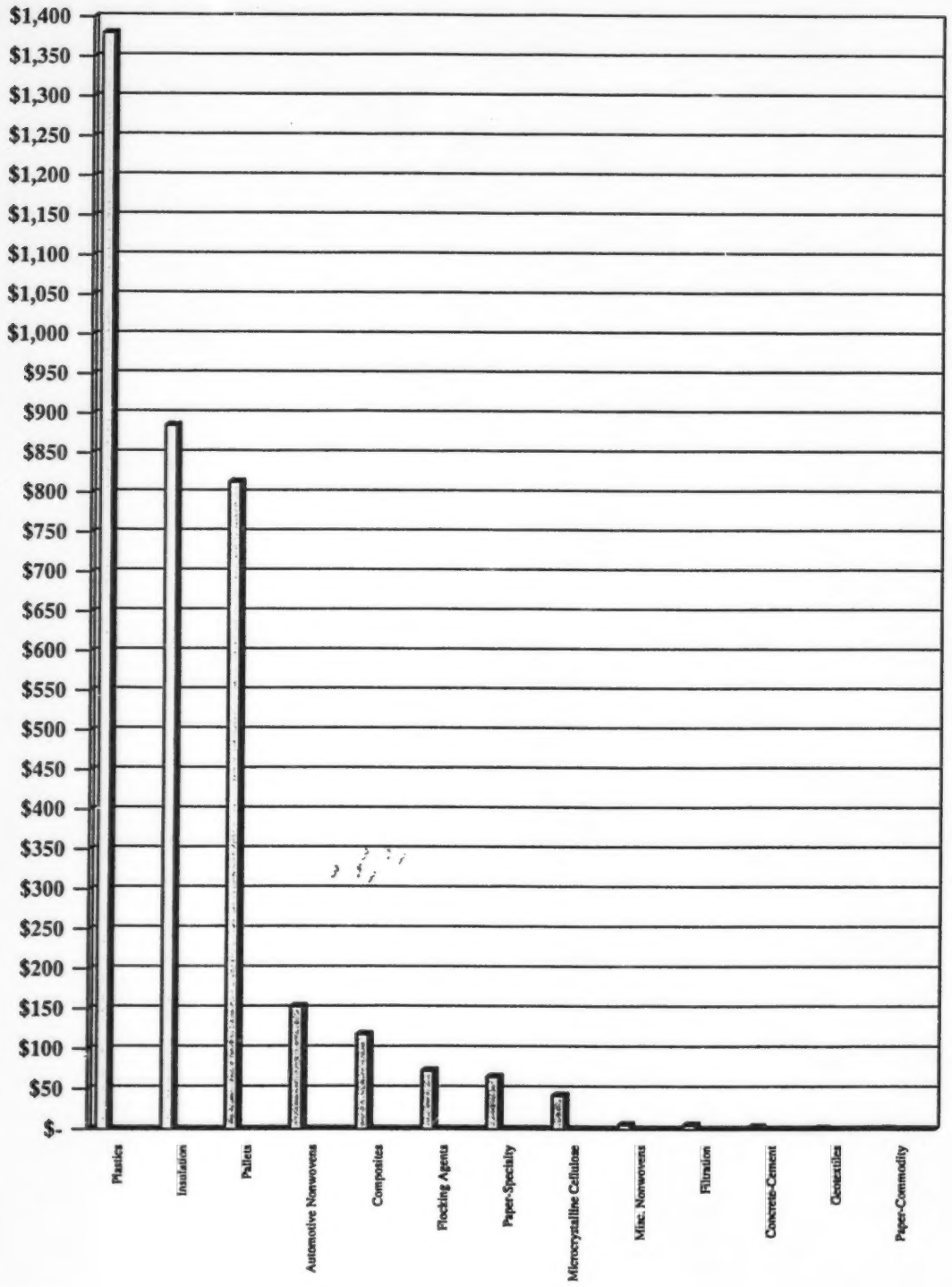
2.1 POTENTIAL BAST FIBRE MARKETS VS. AVAILABLE BAST FIBRE



2.2 POTENTIAL BAST FIBRE MARKETS (MT)



2.3 POTENTIAL BAST FIBRE MARKETS ($US MILLION)



2.4 LEADING MARKETS:

Top Tier:

Automotive nonwovens - moderately-large market of principally interior panels including side door panels, rear quarter panels, package trays, headliners, as well as console parts, tire covers, and other insulating parts of the engine compartment. The industry with the greatest applied market interest in North America at present. Offers attractive prices ranging up to US $925/tonne. At the same time generally desires high quality including purity up to 99% purity and great stiffness.

Reinforcements for composites - very large market, yet only in its infancy in terms of its actual incorporation of agricultural fibers. Pallets and a broad array of industrial and consumer products have the potential to be utilized. This market can often use a relatively broad range of performance and quality materials.

Specialty pulps - a stable, more traditional market of moderate size. Applications include currency papers, high-grade writing papers, cigarette papers, filter papers, and tea bags.

Second Tier:

Insulation - large market, high value, growing in development in Europe, presently of less volume and value than automotive nonwovens within Europe. In a few years, a researcher from The nova-Intitut projects insulating applications will equal that of automotive nonwovens both in terms of volume and value of bast fibre sold, (Lohmeyer, 2000). In North America, sufficient heat, flame, and fire resistance must be added, possibly through boron. Other additives are mentioned, however, often the added unit costs from non-boron additives are higher. Additionally, mat forming capacity is very limited in North America. Kenex, a hemp processor, Mat, Inc., and several tier two or three automotive suppliers offer some capacity. No mat formers appear to offer the desired final thickness for 80 mm or thicker products without double layers. Moreover, air laid systems appear best as they offer sufficient performance with higher efficiency and a lower price.

Third Tier:

Geotextiles- mixed reviews. At first assessment offers market size comparable to automotive nonwovens, and would benefit from inherent characteristics of natural fibers as biodegradability is generally preferred, however, value for such materials is somewhat lower than most other applications and Daike Lohmeyer, a consultant from The Nova Institute, a German bast fibre consulting firm, indicated bast fibres require more complete retting for geotextiles applications. Assuming bast fibres are suitable, geotextile mat processors appear only to be interested in the price were below that of coir (i.e. coconut husk fibre), presently at $300-$400/short ton delivered to Long Beach, California or New York City. Additionally, many regulations make entry of non-traditional materials very cumbersome, moderately expensive, and quite lengthy.

Fibre-reinforcements for cement and concrete - limited testing and market development. Several questions and uncertainties remain as to the compatibility of linseed in this applications, including:

1) Incompatibility likely if the hemicellulose content is too high.
2) It is unclear at this time as to how decorticated flax meets these requirements.

3) Swelling and contraction of flax fibre may be a problem if the concrete is exposed to wet and dry cycles.
4) Flax fibers may rot before the concrete wears out and thus strength would be reduced to an unacceptable level.
5) Flax fibres may not bond sufficiently to concrete under certain applications.

Market is small, but growing. Additional research and market development is necessary to determine the degree of compatibility and extent of market potential.

Fourth Tier:

Filtration Materials: A several billion dollar industry. Applicability of bast fibres unclear, but could amount to $5 million in fiber sales under beneficial circumstances. Bast fibres may offer synergistic opportunities when mixed in smaller proportions with other materials. Significant market understanding, product testing, and market development are critical if market is to be developed, as at present very little effort has been expended in this market.

Separation Materials: Sizeable industry, applicability of bast fibres in this market is also unclear. Bast fibres may offer synergistic opportunities when mixed in smaller proportions with other materials. As with filtration materials, significant market understanding, product testing, and market development are critical if market is to be developed.

Other nonwovens - Virtually non-existent product, process, and market development in these sectors. Some markets are very large and intuitively some synergistic effects from bast fibres are likely.

2.5 MAJOR PROCESSORS AND MARKET PLAYERS[2]

Top Tier:

Durafibre Limited. - Linseed flax decorticator and marketing organization.

Location: Canora, Saskatchewan (Production Plant)

Second Tier:

Schweitzer-Mauduit, Specialty Pulp and Paper Producers, with focus on Flax

Technology: Simple, low-cost low purity flax decorticator exclusively supplying affiliate pulp mills principally for cigarette papers.

Location: Winkler, Manitoba - Decortication. Ancram, New York; Lee, Massachusetts; Spotswood, New Jersey - Pulp Producers

[2] Critique:

Note: Tier ranking are based upon a weighed combination of the following:

1) Their practical demonstration in manufacturing,
2) Applicability to the ultimate use of Saskatchewan grown bast fibre crops, and
3) Overall merits, particularly technical, marketing, business, financial, and personnel.

Third Tier:

Biolin Research, Inc., Fibre Flax development in the Canadian Prairies.

Technologies: Varied pursuits. Comparison between linseed and fibre flax.

Location: Saskatoon, Saskatchewan

Kafus Industries, Ltd. - Diversified green materials processor, focusing upon commodity products.

Technologies: Various, kenaf decortication and marketing, bast fiber based automotive non-woven mat production.

Locations: Management in cities of residence
Elkhart, Indiana - Automotive nonwovens plant
Raymondville, Texas - Kenaf decortication and marketing.

Alpha Fibre, Ltd. -Agricultural Residue Fibre-Enhancement Development Company.

Technology: Agricultural Residue Fibre-Enhancement used in composites.

Locations: Management in city of residence, not yet in production.

Can Ag Research & Development, Health Food Nutraceutical Company with a growing focus toward the use of bast and core portions of both hemp and linseed flax.

Technologies: Hemp oil-seed and/or meal-based technologies and plant breeding.

Location: Prince Albert, Saskatchewan.

Urban Forest Recyclers, Inc. Small, but diversified pursuits ranging from egg cartons to particleboard with an apparent ongoing interest in utilizing linseed.

Technologies: Traditionally has used recycled newsprint which is then pulped to form egg cartons. Also operates two small-scale Compak particleboard production facilities.

Locations: Swift Current, Saskatchewan, Plummer, Idaho and Hutchinson, Kansas.

FlaxTech, Flax decorticator apparently pursuing geotextile production.

Technology: Flax decorticator and possibly geotextile production.

Location: Rock Lake, North Dakota

Ecusta, Specialty Pulp and Paper Producer, with focus on Flax

Technology: Simple, low-cost low purity flax decorticator exclusively supplying affiliate pulp mills principally for cigarette papers.

Locations: Treherne, Manitoba - Decortication. Brevard, North Carolina- Pulp Producer

Kenex, Ltd. Hemp Fibre and Core Processor and Nonwoven Mat Former and Hempseed Processor

Technologies: Moderately sophisticated decortication unit from Europe and used nonwoven mat line. Decortication system has low throughput and probably lower recovery proportions at high purity.

Location: Pain Court, Ontario

Hempline Inc. - Hemp Fiber and Core Processor

Technologies: Moderately customized decortication system, reportedly capable of higher quality.

Location: Delaware, Ontario

Fibrex Quebec, Inc. - affiliated with Quadrant-Pacific Capital Corporation - Fibre Flax Decorticator

Technologies: Suitable European flax decortication equipment likely obtained at deeply discounted price through bankruptcy sale.

Location: Salaberry de Valleyfield, Quebec

KenGro Corporation - Kenaf decorticator

Technologies: Longer-term experience with decortication and marketing, particularly core portion.

Location: Charleston, Mississippi

Fourth Tier:

Consolidated Growers and Processors, Attempted Hemp Production Conglomerate.

Recently declared bankruptcy.

Technologies: Acquired stake in several European hemp initial processing technologies.

Locations: Germany, France, Switzerland, and Winnipeg.

Parkland Industrial Hemp Growers Co-op Limited, Hemp Growers Cooperative

Technologies: Considering various value-added processes for industrial hemp, particularly with oilseed.

Locations: Dauphin, Manitoba

Intermediaries:

Danforth International, Specialty Fibre Broker and diversified related pursuits.

Business: Distributor, Specialty fibres and miscellaneous manufacturing and consulting pursuits.

Location: Point Pleasant, New Jersey

International Filler Corp., Distributor, marketer of broad array of fillers and cellulosic flock.

Business: Markets and distributes fillers, specifically cellulose flock, cotton flock, synthetic flock, and sisal flock.

Location: North Tonawanda, New York

FlaxCraft - Flax and hemp fibre broker.

Technology: Knowledgeable in retting techniques and growing practices, European business, Automotive markets.

Location: Tenafly, New Jersey

2.6 INDUSTRY VOLUME POTENTIAL AND GROWTH RATES:

		Bast Fiber			Finished Product with Bast Portion		
	Growth Rate %	Content Volume MT	Sales Revenue US$ (in millions)	Unit Value US$/MT	Content Volume MT	Sales Revenue US$ (in millions)	Unit Value US$/MT
Geotextiles:							
Erosion Control Mats	2.0%	2,092	$ 0.6	$ 308	4,184	$ 10.0	$ 2,381
Soil Stabilization Blankets:	2.0%	314	$ 0.1	$ 400	628	$ 1.7	$ 2,646
Automotive Nonwovens	8.5%	204,119	$ 153.0	$ 750	408,237	$ 849.4	$ 2,081
Insulation: Thermal & Thermo-acoustic	2.3%	1,003,801	$ 885.2	$ 882	1,091,088	$ 2,694.1	$ 2,469
Filtration: Fabric filter sys & elements	35.0%	5,528	$ 5.1	$ 926	5,528	$ 25.3	$ 4,568
Other nonwovens:		6,000	$ 5.4	$ 904			
Pallets:		900,000	$ 813.5	$ 904	1,800,000	$ 4,200.0	$ 2,333
Composites: Fiber-reinforced Thermoplastics:							
Transportation Market	9.1%	22,680	$ 24.0	$ 1,058	45,360	$ 90.0	$ 1,984
Construction	6.3%	55,248	$ 58.5	$ 1,058	110,496	$ 219.2	$ 1,984
Consumer Products	16.4%	20,503	$ 21.7	$ 1,058	41,005	$ 81.4	$ 1,984
Electrical/Electronic	6.3%	1,538	$ 1.6	$ 1,058	3,075	$ 6.1	$ 1,984
Corrosion-resistant	2.1%	1,550	$ 1.6	$ 1,058	3,100	$ 6.2	$ 1,984
Marine Applications:	-2.2%	10,000	$ 10.6	$ 1,058	20,000	$ 39.7	$ 1,984
Total:		111,518	$ 118.0	$ 1,058	223,036	$ 442.5	$ 1,984
Other Plastic Products		1,391,019	$ 1,380.0	$ 992	2,782,038	$ 5,520.0	$ 1,984
Commodity Paper/Pulp:	2.0%	900	$ 0.7	$ 772	900	$ 1.9	$ 2,102
Technical Specialty Papers:							
Food Products:	2.0%	16,934	$ 12.3	$ 728	16,934	$ 79.7	$ 4,705
Medical:	3.0%	7,395	$ 5.4	$ 728	7,395	$ 35.1	$ 4,753
Filtration:	2.0%	64,125	$ 46.7	$ 728	64,125	$ 301.7	$ 4,705
Industrial: Substrates	5.0%	8,470	$ 6.2	$ 728	8,470	$ 67.2	$ 7,930
Total	3.0%	89,437	$ 65.1	$ 728	89,437	$ 483.7	$ 5,408
Cement and Concrete Fibre Reinforcements:							
Cement Reinforcement -Siding:	Moderate	4,800	$ 2.6	$ 550	4,800	$ 2.6	$ 550
Wall Panels, Fake Rocks, & Waterscapes		150	$ 0.1	$ 730	150	$ 0.1	$ 730
Flocking Agents	3.0%	27,937	$ 72.9	$ 2,610	27,937	$ 72.9	$ 2,610
Microcrystalline cellulose	4.0%	7,350	$ 41.9	$ 5,700	7,350	$ 41.9	$ 5,700
Total:		3,754,966	$ 3,544.3	$ 944	6,445,314	$ 14,346.0	$ 2,226
Risk Adjusted Totals:		1,461,400	$ 1,358.5	$ 930	2,554,230	$ 5,655.9	$ 2,214

2.7 AVAILABILITY AND COST OF TECHNOLOGY:

The following costs are approximate and are for equipment only, and do not include building, infrastructure, and miscellaneous start-up costs. All the following prices are in US Dollars.

DECORTICATION:

Actual costs can vary markedly depending upon actual purity target and the specific components and technologies employed. Machinery Costs, less building:

Crude Decortication

- Simplest Decortication
- Lowest Unit Priced Decortication

Due to Lower Purity, 80% and below only suitable for more limited applications, including specialty papers (as Ecusta and Schweitzer-Mauduit) are doing, and lower requirements for a range of composite products (generally requiring a minimum of 70% purity fiber).

For Hemp and Kenaf:

5 TPH:	$600,000
10 TPH:	$1,050,000
20 TPH:	$1,950,000

For Flax:

5 TPH:	$700,000
10 TPH:	$1,200,000
20 TPH:	$2,200,000

Moderate Decortication

- Extension of more crude decortication
- Moderate Unit Priced Decortication
- Moderate purity, 80%-95% purity, Suitable for many composite applications, particularly those for which the core can be used as a low cost filler.

For Hemp and Kenaf:

5 TPH:	$1,000,000
10 TPH:	$1,750,000
20 TPH:	$3,250,000

For Flax:

5 TPH:	$1,150,000
10 TPH:	$2,010,000
20 TPH:	$3,730,000

High-Purity Decortication

- Most complex technology to maintain higher purity at acceptably high throughput

- Higher priced decortication
- High purity, 95%-100% purity.

For Hemp and Kenaf:

5 TPH:	$1,700,000
10 TPH:	$3,000,000
20 TPH:	$5,520,000

For Flax:

5 TPH:	$2,000,000
10 TPH:	$3,500,000
20 TPH:	$6,440,000

Fibre enhancement:
$600,000 - $10,000,000

Pelletizing:
$200,000 - $1,400,000

Air-laid non-wovens line
$2,500,000 - $9,000,000

Carded non-wovens line
$5,000,000 - $15,000,000+

Plastic composites: RTM, extrusion, pultrusion, and compression molding
$2,000,000 - $20,000,000

Panelboard Manufacturing
$3,500,000 - $27,000,000 - low-cost agro-fiber based equipment manufacturers
$45,000,000 - $70,000,000 - standard premium wood-based equipment manufacturers

Decortication is not publicly available but in from Hill-Agra, Stover, and a few European manufacturers. Fibre enhancement is available only on a limited basis and is generally best determined through the use of a skilled industry professional. All other manufacturing processes are readily available. In all such pursuits of value-added manufacturing, one should know or hire the services of skilled industry professional.

2.8 COMPETITORS AND COMPETING PRODUCTS:

Competing Products:

Bast fibre:

Hemp, kenaf, jute, sisal, sunn hemp, ramie, abaca, cotton, glass fibers.

Core/Shive fiber:

Wood flour, ground straw, calcium carbonate, and talc.

Competitors:

Bast fibre:
Kenaf: Kenaf International, KenGro, Ankal
Jute: Dixie Manufacturing
E-Glass fibers: Owens Corning, Johns Manville, PPG, and Vertrotex Certainteed.

Core/shive fiber:
Wood flour: American Wood Fibers, P.J. Murphy Forest Products Co., Ace International
Calcium Carbonate: Georgia Marble, Genstar, Thompson, Omya, Huber, and White Pigment
Talc: Luzenac, Cyprus Industrial Minerals, Polar Minerals, and SMI

3.0 OPPORTUNITIES FOR GROWERS COOPERATIVES:

Some groups promote the concept of growers cooperative in processing, otherwise known (at least in the United States) as a New Generation Cooperative. Fundamentally, New Generation Cooperatives (NGC) can offer an excellent opportunity for growers to participate more directly in value-added manufacturing and the often much greater profitability value-added manufacturing offers. Cooperatives appear best suited for relatively established pursuits, such as the processing of a particular established product utilizing well-established equipment.

Bast fiber processing is not a strong match for an NGC. Bast fiber decortication, fiber enhancement or other value-added manufacturing incorporating bast fibers is not well established. Rather, business ventures in this sector rely upon proprietary technology. Such technology is generally developed through either a larger company or, more likely, entrepreneurial firms that are better suited to attempt coordinating the specialized technical, marketing, and financial resources.

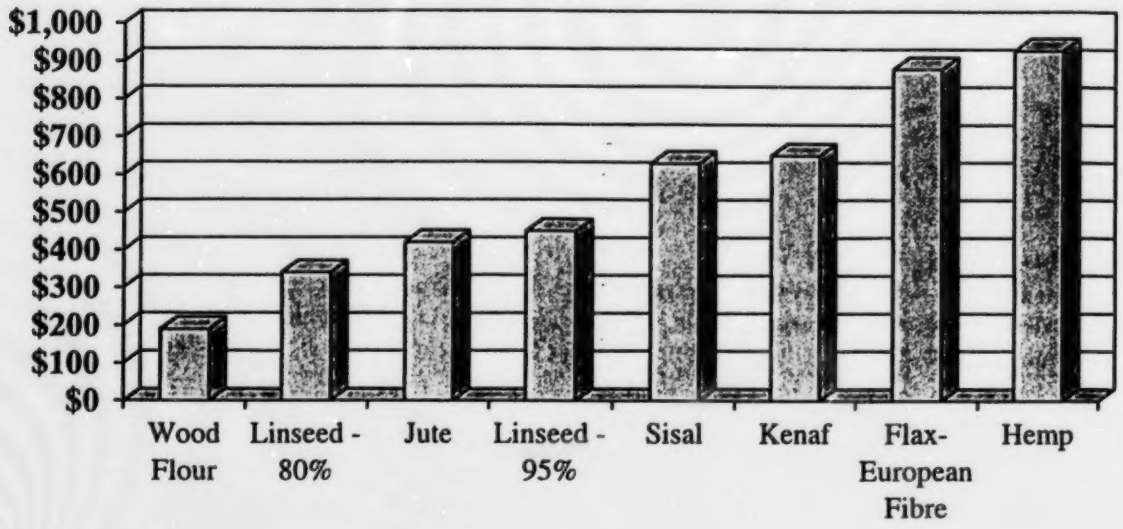
If the legal cooperative structure should allow entrepreneurs, developers, and technology and/or market specialists to join with growers in the ownership and management of the processing venture, however, opportunities to use a cooperative framework could succeed in both hemp fiber and oilseed processing.

One option would be to provide non-growers with a portion of ownership of non-voting shares. This arrangement may be more palatable, but may not be sufficiently attractive to entice needed technology developers and entrepreneurs to join with growers (Frederick, 2000). A few groups are pursuing an LLC or C-Corporation Status so that technology developers, entrepreneurs, and other non-growers can join with growers to share in the risks and rewards from a processing or manufacturing enterprise using agricultural raw materials. This structure allows a place for all. Although it retains some technical legal liabilities, these are unlikely to be challenged (Frederick, 2000).

4.0 FIBRE PRICES:

4.1 COMPARATIVE FIBRE PRICES

($US/MT) BASED UPON MODERATELY-HIGH USAGE 2,000 MT/yr



Prices based upon Summer 1999 Survey for natural fibre with 98% target purity.

Kenaf: $0.07 - $0.09/# FOB Georgia. Price dependent upon volume, assumed minimum of 800 MT/yr. *Warning: Ultimate delivery and capabilities unlikely achievable, source does not seem credible!*
$0.25-$0.30/# FOB southern Texas. *Quantities may initially be limited, recent quality improvements.*

Sisal: $0.26-$0.27/# FOB Mississippi. *Instability of supply and consistency of quality of some concern.*

Jute: $0.05-$0.10/# FOB Bangladesh. $0.17/# FOB Virginia.
One source earlier reported $0.06 - $0.09/# FOB Massachusetts. Purity and available quantities uncertain. Jute is viewed as being very risky as inconsistent quality is common. Color/dying retention problems also evident. Still in spite of these conditions, jute offers the potential of very attractive values.

Linseed: $0.14/# FOB Saskatchewan @ 80% purity, $0.19/# FOB Saskatchewan @ 95% purity

Flax:? One source earlier reported $0.06 - $0.09/# FOB Massachusetts. *Purity and available quantities uncertain. Current pricing and ability for subsequent sales unclear.*

Flax: $0.30-$0.36/# FOB Europe. $0.01 - $0.02 reduction for larger quantities. $0.35-$0.40/# delivered to Great Lakes Port.
Price range is reflective of quality and consistency.

No other North American suppliers presently exist to meet purity requirements. One or two suppliers may soon be able to meet these criteria.

Hemp: $0.40-$0.42/# FOB Ontario - two suppliers.
Various suppliers in Europe can presently provide product at a comparable prices, albeit FOB Europe.

5.0 PROCESSING AND TECHNOLOGY OVERVIEW:

5.1 Chopping Whole Stalk

- Simplest, lowest technology
- Lowest investment costs
- Limited markets require the natural ration of bast to core
- Above average market development likely required
- Lower returns likely
- For a company with either limited capital or a strategic broad long-range, long-term technology and substantial, very strong market development focus, could well be the best place to begin.

Applications: Concrete and cement additives, most well established; nevertheless, a market with still limited development.
Panelboard fiber filler (costs too high for particleboard and MDF and questionable for OSB, performance uncertain for OSB, and aesthetics too poor for MDF and probably particleboard).
Applications needing absorbency and strength. Difficult for flax, much more suitable (due to markedly higher absorption rates) for hemp, kenaf, ramie, and probably jute. Flax would require an application requiring a slow, uniform rate of absorption, even though the final absolute absorption amount could be comparable to other bast fibers.

5.2 Crude Decortication

- Simplest Decortication
- Lowest Unit Priced Decortication
- Due to Lower Purity, 80% and below only suitable for more limited applications,

Applications: Specialty papers (such as material from Ecusta and Schweitzer-Mauduit)
A range of composite fillers (generally requiring a minimum of 70% purity fiber).

5.3 Moderate Decortication

- Extension of more crude decortication
- Moderate Unit Priced Decortication
- Moderate purity, 80%-95% purity,

Applications: Suitable for many composite applications, particularly those for which the core can be used as a low cost filler.

A few automotive nonwoven mat processors capable of handling lower purity fiber, generally around 85%.

5.4 Moderately-High Purity Decortication

- More complex technology to maintain higher purity at acceptably high throughput
- Higher priced decortication
- High purity, 95%-98% purity.

Applications: High quality composite fillers,
Potentially, a few automotive mat producers

5.5 High Purity Decortication

- Most complex technology to maintain highest purity
- Throughput of end product (at highest purity) is often reduced to a lower level
- Highest priced decortication
- Highest purity, 98%-100% purity.

Applications: Highest quality composite fillers,
Most automotive mat producers

5.6 DECORTICATION TECHNOLOGY REVIEW AND CRITIQUE:

A review of decortication (i.e. fiber separation) systems and of select value-added processes to maximize the value of all portions, particularly the bast fiber from flax and hemp.

The European manufacturers originate from a fibre flax textile background with their equipment originally designed to process long-line fibre flax for applications in textiles. Modifications to this equipment have been made for hemp, as well as post-decorticated chopping for shorter length cottonized processing. European equipment have the highest level of reliability and is most likely to process as to ones specifications, however, LaRoche and Charle - Temafa have only limited experience with larger throughput and their equipment is quite expensive. The lower throughput from the European equipment coupled with its high cost results in quite high unit decortication costs. A new Western European decortication manufacturer is reported to be developing a competitive decorticator to be introduced around Summer 2000. Details including precisely who remain unclear. Higher throughput and correspondingly lower unit costs appear to be priorities in this new design that better fits a North American model. Hemp-Flax in the Netherlands offers the highest stalk throughput in Europe (5 TPH), however, the design is proprietary and the purity is reportedly only 80%. Other decortication units in Europe are reportedly 2 TPH or less.

North American units offer the potential of higher throughput and much more reasonably priced equipment. Confidence that this equipment will truly work as desired is quite suspect at this formative stage of development and further product and process development is nearly essential.

The Stover equipment has received mixed reviews with concerns over the equipments ability to obtain the highest levels of purity often required in the automotive industry. For more information interested parties may contact Stover's President, Jimmy Stover at (800) 689-7740, (361) 884-8961 or www.stover-equipment.com. Stover's equipment is implied to be in commercial production processing kenaf. Stover's equipment has proved less successful in at least initial efforts in processing linseed flax.

Hill-Agra's equipment appears promising, however, complete cost estimates require more complete determination. Hill-Agra greatest liability today is that apparently thus far no one is using his equipment for actual production. In order for optimal processing and rather specialized harvesting and initial processing system are required. Such a system arguably has strong rational and merit, however, it clearly adds additional start-up capital requirements - something avoided by nearly all such players. BioComposite Solutions believes Hill-Agra offers some solid engineering and improvements over many options and is worthy of serious consideration, particularly for any processors able to use longer fiber lengths.

BioComposites Solutions believes that in long term the incorporation of off-the-shelf and slightly modified industrial component offers some of the better long terms prospects for success - particularly in processing shorter, chopped fiber lengths. Clearly, much further development is required to achieve reliability, high purity, high throughput, and ultimately low unit decortication costs.

5.7 UNIT PROCESSING COSTS

Unit decortication processing costs are a critical element in determining an operations ultimate profitability. Per unit processing costs have ranged from approximately US $600/tonne[3] for higher purity Mississippi kenaf and some European flax and hemp processing to under US $80/tonne of stalk. In order to achieve economic viability Durafibre's costs need to be close to the low end of this range of processing costs. As linseed flax has a lower percentage of bast fiber than most other varieties of bast fibres, the decortication costs attributed solely to the bast fibre portion increase correspondingly. In detailed analysis, BioComposite Solutions has found that unit processing costs are substantially reduced for greater throughput and greatest equipment utilization. To date, the best processors can only process 5 - 10 tonnes (generally 5 tonnes) of stalk per hour per decortication line. Moreover, as target purities reach the final 5 percent, throughput decreases considerably. The strength and toughness of the outer bast fibre coupled with the relatively low bulk density preclude the processing of greater quantities in any one piece of equipment. Thus substantial processing efficiencies are realized at 5 tonnes per hour capacities, depending upon the equipment chosen moderate improvements are realized from 5 - 10 tonnes per hour. Beyond these amounts improved efficiencies are slight resulting principally from lower maintenance, spare parts, and personnel savings.

The second aspect is the utilization of the decortication equipment. Even though storage is significant, established linseed stalk processors Ecusta and Schwietzer-Mauduit, have a model of sufficient storage to allow year-round processing. BioComposite Solutions strongly recommends year-round decortication as this best utilizes the equipment capitalization, while providing lower hourly throughput to meet annual production goals. In general, lower hourly throughput allow

[3] Costs are based on US dollars/metric tonne of stalk. Linseed flax having generally lower bast content and lower core/shive value will have correspondingly higher decortication costs if such costs are exclusively allocated to the bast fiber portion.

the decortication equipment to achieve higher purity and greater consistency, two strongly desired qualities. Turning to weekly shifts, clearly a two-shift operation offers considerable savings over that of a single operation. A three-shift operation allows for more constant operating conditions resulting in smoother, more consistent settings and adjustments. A fourth swing shift offers a slight potential for even further productivity from the equipment, however, BioComposite Solutions believes a fourth shift offers more liabilities through a staggered work schedule for all employees, and weekend equipment maintenance is desirable and would be substantially reduced in this arrangement. Moreover, a two day break allows ample opportunity for continued progressive decortication system development and upgrades, a technology which is certainly in its infancy in which much greater technical equipment improvement is essential to provide processors with greater opportunity for improvement.

A key unit processing cost factor is purity and other fibre quality targets. Experience shows that at this time virtually all bast fibre decorticators struggle to achieve the highest possible levels of purity demanded by customers at acceptable levels of throughput and ultimately unit costs. The pricing structure of bast fibre decorticated materials demonstrates a marked, moderately exponential rise in costs as fibre purity approaches complete 100% purity.

Finally, decortication technology development offers the opportunity for continued improvements in these areas. The pace of these development is difficult to project as nearly all processors keep the details of their process proprietary and guarded. Equipment manufacturers such as LaRoche, Charle-Temafa, Hill-Agra, and Stover are moderately open. For example, the details from European LaRoche and Charle-Temafa are rather limited. Hill-Agra has produced relative little decortication equipment thus far and keeps many of his various design ideas private. In 1999, Stover had required potential viewers of his equipment to sign a non-disclosure agreement. This may be now be loosened as his patents are granted. Nevertheless, machinery developers assisted by associated consultants and bast fibre processors should lead to moderate to substantial process improvement even though the pace may be erratic.

By following a three-shift, year-round 5 tonne/hour decortication operation, 95% purity fibre can have unit processing costs of US $55-100/tonne of stalk. 10 - 20 tonne/hour throughput can demonstrate unit processing costs of US $30-$80/tonne of stalk. Obviously, if all the decortication costs were attributed to the bast fibre fraction, the unit processing cost would increase by a factor of 3 - 4 times.

6.0 PATENT & TECHNOLOGY CONSIDERATIONS:

Patents can be significant forces in a particular industry. At this time, however, BioComposite Solutions is not aware of any active approved patents that are critical within this industry. Several groups have developed decortication patents. Although none of these patents appear to be particularly critical to others in the industry. Recent examples include US Patent 5,970,582 by Stover in Texas and US Patent 6,079,647 for Durafibre in Saskatchewan. Others treat their gained knowledge as proprietary, while not pursuing patent protection per se. A majority of bast participants has chosen the latter route, as opposed to the former technique.

Nevertheless, a moderate increase in bast fibre technology patents are likely in the next five to ten years. Stover has indicated they have a patent pending. Other active or potential developers, processors and manufacturers are rumored to be exploring patent protection. Three key areas of patent protection exist: 1) Decortication technology, 2) Fibre-enhancement and related

processing technology, and 3) Product development and application patents which consist of new products or existing end products using novel (bast) materials.

Since bast and leaf fibres are more common in a number of smaller developing countries in tropical and sub-tropical regions including China, adequate patent protection is both expensive and uncertain.

7.0 FACTORS AND TRENDS DRIVING THE MARKETPLACE:

In terms of product development Europe is a clear leader in technical development. Asia, namely the region from India to China has probably the greatest market penetration of bast fibres, along with similar strong, stiff natural fibres including abaca, sisal, and coir. Technologies in these areas tend to be less technically refined and sophisticated. South America, Africa, and Oceania presently have small levels of both production and product and market development. North America should try to learn as much as possible from Europe, particularly in terms of technical matters. North America in the mid-term is more strongly positioned to utilize its lower land costs (as compared to Europe), greater economies of scale, and stronger entrepreneurial and market development drive to establish larger successful bast production facilities. In the longer term, this model may be transferred to tropical and subtropical growing areas in developing regions.

Trends depend upon markets:

7.1 Automotive nonwovens:

- Worker hygiene, bast fibres lack itchiness that occur when handling glass fibres.
- Western Europe has led North America in developing technologies to utilize and incorporate bast fibres in automotive nonwovens.
- Has potential, although some have not yet realized this benefit yet, to be lighter than resultant composites from glass fibres.
- Clearly has greatest eagerness to embrace bast fibres.
- Worldwide automotive nonwovens market is $894 million.

Steve McNally from the Composite Fabricators Association stated that bast fibres offer a number of advantages in automotive nonwovens, namely the following:

1) Ability to process at lower pressures and temperature than e-glass materials.
2) Quicker mold cycle times.
3) Lower tool costs.
4) Lower energy costs.
5) Lower raw materials cost, as compared to e-glass.
6) Reportedly lower resin demand.

McNally also stated he believed automotive interior nonwoven panels were the best application for natural fibres due to these advantages.

In the automotive nonwovens industry in Europe, as well as North America, it seems quite likely that into the mid-term bast fibres appear likely to experience moderate growth. In a report released January 2000, The nova-Institut, surveyed 16 German manufacturers representing about 80-90% of the suppliers processing natural fibres. According to those surveyed, these

manufacturers processed approximately 14,400 MT of bast fibres for the automotive nonwovens industry. Of this amount, 11,000 MT came from flax, 1,100 MT of kenaf, and 1,100 MT of hemp, 700 MT of jute, and 500 MT of sisal. Thus, 76.4% of the natural fibre used was flax, with kenaf and hemp each drawing a 7.6% market share. In 2000, 15,000-20,000 MT are projected to be processed for use in the automotive nonwovens market.

7.2 Geotextiles:

- Natural fibres have the technical and theoretical potential to be more compatible for this application than any other.
- Worldwide geotextile market of $896 million is nearly identical to the size of the automotive nonwovens market.
- Pursuit of this market by bast processors has been limited to date.
- Historically has used strong fibres internationally.
- Erosion control mats is the market presumed to be the best fit for natural fibres.
- Soil compaction mats also hold promise, but are less developed.

Many natural fibres used in erosion control mats are cereal straws that are very inexpensive. Even the more expensive coir fibre from coconut husks in Sri Lanka or India are only $300 - $400 per short ton delivered to Long Beach, California or New York City. (Deliveries to New York City are towards the lower end of this spectrum, while shipments to Long Beach are on the upper end of these prices.) Even though it appears bast fibres would fundamentally be a suitable choice for erosion control mats, the prices customers appear willing to pay are quite low. The fibre can have lower purity and greater inconsistency may be more permissable in these applications, still manufacturers seek to pay a lower price for these fibers than for coir. Additionally, it is a long tedious process to have bast fibres tested and approved for use in many states. Canada and many private groups appear to have a more open policy to alternate fibres. Still broad based acceptance is likely cumbersome and ultimate profits are likely to be very low greatly reducing the incentive for these fibres.

AGRO-BASED GEOTEXTILES

Geotextiles are any textile like material, either woven, non-woven, or extruded, used in civil engineering applications to increase soil structural performance. The main structural performance functions geotextiles provide are aggregate separation, soil reinforcement and stabilization, filtration, drainage, and moisture or liquid barriers (Dewey, 1993). The market for geotextiles is growing, with worldwide sales of over 700 million square meters annually (Sen Gupta, 1991). Polypropylene is the material of choice for about 80% of all geotextiles. Polyester accounts for about 15%, and polyethylene and nylon about three percent. The remaining two percent consists of agro-based materials. Even then, only a few are 100% natural fiber-based. Many of these contain some portion of synthetic material to hold the geotextile together. This is normally a polypropylene net or polyester scrim sheet that sandwiches the agro-based component. Most geotextiles applications are permanent, such as landfill liners and roadway construction, and the use of agro-based, biodegradable materials would have adverse results. Other applications, though, are temporary or short term, and the use of agro-based, biodegradable materials is worthy of consideration.

Commercially, there is a good variety of geotextiles available that contain a majority percentage of agro-based materials. The agro-based materials are used because of their low cost, biodegradability, moisture-holding ability, and environmentally friendly image. Most are, used in erosion control where they serve to stabilize the soil surface while natural vegetation is established. Some of them contain seeds to accelerate and control the re-growth. Other applications include

mulches, and the related products of filters and sorbents.

Data conflicts on the amount of erosion control geotextiles sold, with estimates for North America ranging from 22-73 million square meters. According to Homan (1994), agro-based materials make up about 60 percent of the erosion control market. Regardless of the number, erosion control geotextiles markets are growing at 10-15% a year overall.

Ref. Paper and Composites from Agro-Based Resources, ed. By R. Rowell, R. Young, and J. Rowell, CRC, 1996.

7.3 Specialty Papers:

High performance natural fibres, namely flax, hemp, sisal, abaca, and cotton are the only types of fibres that meet the performance criteria. Domtar, traditionally a commodity paper producer, began 1 March 2000 to produce in their Ste. Catherines, Ontario paper mill to make a specialty100% non-wood paper line to demonstrate their environmental orientation. Hemp at a minimum 15% content is added to sugarcane bagasse. At this time, the pulp is purchased from a specialty non-wood pulp producer in Spain. Domtar pays CDN$2,800/air dried short ton for the hemp pulp. Their initial paper production run is 200 tons. Total sales of 600 tons is forcast for the first 12 months of production, hopefully growing moderately over time. Under these assumptions 100 tons of hemp pulp would be used in the first 12 months. Hemp was chosen based upon its desirable environmental marketing features, not performance or value per se.

7.4 Fibre-reinforced Thermoplastics:

- Natural fibers can offer lower priced reinforcements.
- Bast fibres meet the higher value and performance end of this spectrum.
- Promoted by natural fibre processors as offering better value than alternatives; for bast fibres, these alternatives are glass fibres.
- A few scattered pursuits by wood flour, bast and leaf fibres, and a few other fibre processors have pursued these markets.

7.5 Diapers and other Potential Sanitary Products:

At least one large sanitary nonwoven producer is reported by a fiber broker to have an interest in non-wood fibres, quite possibly bast fibres. Any such developments in these areas have tremendous implications, but are being kept secret at this time.

Cotton is also being tested as a potential substitute to bleached wood pulp fluff. Earlier efforts obtained only limited interest due to higher cost from cotton. The more recent use of shorter, less expensive cotton from linters offers attractive value.

With the exception of the established specialty paper market and the upcoming automotive nonwovens markets, others bast and shive markets are primarily untapped. The leading marketing dynamics are that natural fibre entrepreneurs believe that outstanding margins and market potential exists if natural fibres in some form, particularly bast fibres, are used as reinforcement agents. Bast fibres typically can be used to replace more expensive glass fibres. Generally, in all these other markets the fibre processor needs to market its fibre directly to compounders, shoddy manufacturers, nonwoven processors, and various composite producers.

In more developed markets, the case could also be made that lower priced bast fibres fill a void between applications that definitely require fibre reinforcements and those applications that are too thin to require fibre reinforcements at almost any price. Thus, in this scenario, composite producers could be shown that a less expensive formulation would be to create a thinner piece using lower cost fibre reinforcements and less resin resulting in the lower material cost, having the added benefit of being thinner and lighter as well.

7.6 DURATION EXPECTED FROM DRIVING FACTORS:

The continuance of these factors depends upon three elements:

a) The success, publicity, zeal, and drive from groups such as Alpha Fibre, semi-established processors such as Kafus, and more established companies such as Cargill and Cargill Dow Polymers, in addition to any new ventures in this field.

b) The value of developments relating to the attainment of performance standards required in industry by bast fibres, the cost and value of these fibres, new developments such as Cargill Dow Polymers, Alpha Fibre, and particularly gene-splicing biotechnology techniques originally started by Monsanto, DuPont, Dow, and others. The value of these preceding developments relative to the extent of continued glass and synthetic developments.

c) Any pro-chemergistic legislation or pressure manufacturers may experience. Little sign of this appears to be developing on the horizon. If Al Gore were to elected President of the United States, or an expansion of current Western European attitudes transferred to North America, it is slightly more possible such action might develop. More likely biotechnology and recombinant DNA technology could lead us to pursue natural fibre development more fervently.

Overall, these factors appear likely to continue with sporadic growth over the next two years. BioComposite Solutions would project development of these fibres will intensify in years three through five.

8.0 OPPORTUNITIES AND BARRIERS:

8.1 Specific processing opportunities Saskatchewan can develop

Processors who would focus upon:

a) Exclusively decortication.

Beyond basic decortication, other potential pursuits fall into two general categories. i.) Further fibre enhancement, beyond that of Durafibre and ii.) value-added products.

b) *Fibre Enhancement:* Examples include that which Alpha Fibre is pursuing, as well as the general category of steam explosion, namely the use of heat, pressure, and moisture to develop a finer, more fibrillated fibre, and/or a fibre with a greater aspect ratio. A variety of companies have patents in these areas although no companies to date have shown success. Most failures in Europe result from high energy costs and to a lesser degree lower throughput. Such a combination effectively has higher unit processing costs than its effective added value to make the profitability marginal at best.

c) *Value-added Products:* Example include thermoplastic products, nonwoven mats, geotextile mats, thermal or acoustical insulation, and select building materials.

One of the best broad-reaching applications is nonwoven mat formation. Such production can be air-laid, a simpler, process better suited for lower-end composites and thermal and acoustical insulation, or carded. Nonwoven mat formation is strongly needed as an intermediate processing step. The lack of intermediaries, particularly those outside of automotive nonwoven production is sorely lacking, as most non-automotive nonwoven mat formation is tied to non-natural fibre products, particularly glass fibres.

8.2 Barriers to industrial growth and ways to overcome these barriers

1) The lack of sufficient concentrations of linseed flax that make transportation costs prohibitively high, particularly for processes that require very large throughput of fibre.

Solution: Develop incentives and strong communication, potentially through some level of a cooperative structure, create inducements for growers in the immediate vicinity of processing plants to grow more flax near the plant site.

2) Very limited number of likely successful companies that possess the skill necessary for success.

Solution: Governmental and economic development authorities could help coordinate and orchestrate vertical integration of companies to fill out a comprehensive vertically-integrated supply chain.

3) Limited knowledge and recruitment of best potential developers and manufacturers from around the world.

Solution: Development of a stronger presence at critical trade shows and technical conferences, such as the Natural Fiber Thermoplastic Conferences which alternative annually between Madison, Wisconsin and Toronto, Ontario. Limited travel to European conferences could also be considered.

4) Potential lack of sufficient financial incentives and sufficient degree of assistance in the secure of necessary capital and start-up funding for potential developers and manufacturers in Saskatchewan.

Solution: Strong focused publicity and encouragement to potential manufacturing ventures.

8.3 Critical decision factors for plant site location

1) The most critical criteria is a location central to a concentration of quality and higher bast proportion linseed flax. In other words, a preferred location is based upon
   a) a weighting of the least amount of transportation necessary to bring a target quantity of residue to the plant coupled with,
   b) the quality of the linseed as determined by bast fibre content and target performance characteristics such as stiffness, fibre fineness, tensile strength, and ease of decortication (minimal damage to the fibre).
2) The willingness of farmers to adjust their harvesting practices to the greatest mutual benefit to both growers and processor. (Details unlikely to be well known at this point.)
3) Adequate infrastructure of transportation and communication. Proximity to strong research institutions which could assist in continued technical development.

4) A site which minimizes the transportation costs to end target market locations.
5) A location sufficiently far removed from population centers so that any dust resulting from processing the fibre will be minimized in its effect to others.

9.0 FIBRE SUPPLY ISSUES:

9.1 Critical fibre characteristics and qualities required by the market

A prioritized list follows:

1) The most important characteristic for composite and most nonwoven products is stiffness, technically known as modulus.
2) Excellent wetting - the ability to absorb thoroughly a resin matrix into the fibre. Such absorption is valuable for improved bonding, but is even more critical for moisture absorption and resistance to fungal deterioration.
3) In general, the finer the fibre the better.
4) The toughness, impact resistance, and energy absorption - all closely related - are important, particularly in automotive nonwovens applications.
5) A fibrillated fiber may be better for composites and is likely better for absorption and insulating, although limited testing to prove this aspect.
6) Tensile strength has some value.

9.2 RECOMMENDED AGRONOMIC PURSUITS:

As manufacturers begin to process flax in Saskatchewan the following areas of pursuit are recommended:

1) Try to encourage use of varieties with greater a) bast proportions, b) gross bast weight, and c) structural performance characteristics of bast fibres.
2) Attempt to breed varieties with greater a) bast proportions, b) gross bast weight, and c) structural performance characteristics of bast fibres.
3) Encourage, ideally through private producer financial incentives, to grow more linseed flax closer to central processing plant.
4) Determine if current 3-5 year rotation cycle of linseed can be further shortened without moisture depletion or disease concerns.
5) Ultimately try to make linseed varieties of greater value and productivity to encourage further development, resulting in greater available residue.

9.3 RECOMMENDED RESEARCH FOR PROCESS, PRODUCT, AND MARKET DEVELOPMENT

1) Development of improved decortication equipment, specifically allowing target purity at high levels of recovery (% of bast fibre retained) at low unit processing costs, while imparting minimal fiber damage that would otherwise reduce structural performance.
2) In depth assessment of fibre enhancement technologies, such development is coupled with improved wetting and the inherent capability to reach even higher thresholds of structural performance as the more elemental structure is pursued (as noted in the fibril-crystalline example in the technical appendix).

3) A thorough understanding of the inherent characteristics, benefits, and liabilities of linseed flax. An analysis of this set of performance characteristics, modification options capable through select processing and enhancement technologies and their associated costs compared to specific market requirements and performance standards from existing materials.

10.0 SASKATCHEWAN COMPETITIVENESS:

Competitive advantages Saskatchewan has in the development of a bast fibre processing industry.

Saskatchewan possesses the largest amount of bast fibre, or any high performance fibre, residue in North America, and probably the most concentrated in the entire world. Moreover, competitive business climates and reasonable proximity to potential markets, coupled with Canadian currency that seems likely to remain relatively weak to the U.S. currency and low effective unit energy costs provides the foundation for quite promising opportunities to utilize the flax residue in Saskatchewan.

10.1 Geographic Agronomic Competitiveness:

Since linseed is a relatively abundant residue, agronomic competitive is either the most competitive, (as Saskatchewan presently provides the great amount of unused sufficient quality residue of any bast crop) or a moot point as yields, are relatively insignificant, again since linseed stalk is a residue. Nevertheless, if and as more firms begin to more fully tap the Saskatchewan linseed resource, probably in the mid-term say in four to seven years, agronomic coordination to attempt to increase the bast content and stalk yields, and ultimately total linseed production are advisable.

10.2 Market Proximity:

Fair-poor. Projected to be second worst, as most Western and Rocky Mountain Canadian and Western United States locations would appear to be the only viable locations which are at a greater disadvantage. Very limited markets may exist in Winnipeg, some markets exist in Minneapolis region. Leading markets are in Michigan, Ohio, Ontario for primarily automotive, but also composites and a few other applications. Second best markets in Wisconsin, Illinois, Indiana, North Carolina, South Carolina, and Georgia.

10.3 Comparison of Saskatchewan's Competitiveness in providing Economic and Technical Support to Growers, Initial Processors, and Value-added Processors:

The region of the former East Germany offers the highest level of financial support for bast fibre ventures with the government providing up to 50% of the financing required, apparently outright. Such a high level of support is due to the over 20% unemployment rate in the former East German region, a brain and worker quality drain, as the more ambitious people from the region as almost certain to move to the former West Germany for better employment and a healthier economy. Europe also appears to lead in technical support through universities and related research institutions, throughout Germany, The Netherlands, and likely Great Britain, particularly Wales, as well as Denmark, Sweden, and to a lesser extent Finland, France, and Italy.

Turning to North America, in terms of financial assistance Saskatchewan appears to offer one of the most attractive sets of financial support, based upon the present track record in the industry sector. Minnesota appears to be second. Kansas and some other provinces would appear to be third in terms of financial support. Minnesota appears to have a greater total budget to assist value-added agriculture, however, Saskatchewan offers a history of definite support to bast fibre processors unmatched to date by any other except for Mississippi that strongly supported kenaf processing during the period from five to twenty years ago. As implied such support has waned considerably in recent years due in large part to failed and struggling in state efforts, coupled with a shifting USDA policy away from kenaf that has now moved toward flax.

In terms of linseed flax, any USDA public development is more likely to support the Canadian Prairies where 85% of linseed flax production exists than the northern Great Plains, principally North Dakota which has one small upstart FlaxTech. Even in terms of fibre flax, the more established North American companies are Fibrex Quebec and secondarily Biolin, both from Canada, with no notable U. S. producers to date.

Minnesota through AURI, The Agricultural Utilization and Research Institute, offers the best internal business and technical assistance for value-added agriculture and appears to be better endowed than any other state or province while offering the best framework of an overall support structure. Minnesota, has a respectable background in the applications of agricultural residues, but not bast fibres. Recently, Minnesota is becoming educated in terms of industrial hemp and in the next year plans to develop a strong understanding of the comparative assessment and application of a wide range of natural fibers.

Minnesota followed by Kansas offer some on the better opportunities for natural fibre processors. Manitoba, Ontario, and Quebec are reported to offer some incentives. BioComposite Solutions would place these between that of Minnesota and Kansas. Many other states and provinces can support bast fibre development projects under the proper conditions. (Preceding paragraph is a rough projection, based on cursory knowledge.)

11.0 RECOMMENDATIONS AND CONCLUSIONS:

11.1 RECOMMENDATIONS FOR DIRECTION OF RESOURCES INTO FUTURE:

A substantial, notable threshold exists which any processors must contend with and overcome in order to be successful in bast stalk processing. This threshold requires any processor must possess a substantially high level of expertise and resources in marketing, financial resources, and technical expertise. Ultimately one must find markets for the bast fibre product. At this time, market research leads BioComposite Solutions to believe that only automotive producers have a significant interest in natural fibres. Within this sector the approval process generally requires approximately 12-30 months from the time of first contact to the time in which product can be shipping for a substantial industrial order. In virtually all other areas one must convince the party who will buy the bast fibre product of it competitive value. For those processors selling a basic or enhanced fibre product, it can be shown rather easily that bast fibre offer a greater value than glass fibres or other fillers. Nevertheless, processing equipment and parameters must be modified to accept the lower density fibre having different blending, resin compatibility, and processing machinery wear characteristics than convention materials. This example illustrates the magnitude of change which processing must be willing to accept in order to incorporate natural fibres into the processing operations.

If a company were to integrate further value-added manufacturing into their business model, this first problem would be alleviated. Still the finished product would need to be competitive in its market sector. Overall, this scenario allows for easier marketing, density, shipping, and processability advantages as intermediate steps are avoided, as well as the potential to retain further often well-integrated technology and resulting profitability. On the downside, this arrangement also forces higher capitalization costs and a greater level understanding of the technical factors throughout the processing including the final value-added manufacturing steps and well as a thorough understanding of the market for the final value-added product produced.

From a cost perspective, even though fundamentally bast fibres offer excellent potential for solid value relative to competing materials, cost control throughout processing is critically important to maintain economic viability. The basic costs are twofold, the cost of the raw material and the cost of decortication. In terms of the cost of the raw material, concentrated linseed flax growing areas demonstrate a clear advantage in this regard, particularly for processors having an emphasis towards the primary use of the bast fibre portion, as opposed to the core (shive) portion of the stalk. Limited opportunities exist to further reduce these costs for linseed flax as the base price is so very low. It is from this perspective that Saskatchewan possesses a substantial competitive position relative other bast fibre production regions around the world.

Ultimately it may be best in the longer term for processors to be paid somewhat more for the residue, perhaps to a maximum of CDN $40 to even $60/baled tonne fieldside. This could be performed in order to encourage farmers and agronomy developers to achieve the following:

1) Plant more flax in more strategic locations (closer to the processing plant),
2) To work with linseed variety breeders to develop varieties having a higher bast fiber proportion,
3) To apply necessary incentives to encourage farmers to plant those varieties with a higher bast fiber content, and,
4) To better condition the stalk during cutting and initial retting to improve its target structural and processing properties

11.2 KEY PRINCIPLES TO CONSIDER:

1) *Outstanding mid-term potential for linseed stalks*
   Through extensive interviews, research, and analysis BioComposite Solutions believes that outstanding mid-term potential exist for bast stalk materials, particularly from the bast fibers. Within this development, oilseed flax residues are arguably the best place to first pursue as the cost is the lowest, yet the quality for nearly all potential markets except probably apparel from linseed flax is adequate.

2) *Prairies offer the lowest cost adequate quality bast fiber*
   Oilseed flax residues from the Upper Great Plains and particularly the Canadian Prairies, when sufficiently concentrated, offer the lowest cost adequate quality bast fiber. For startup developers this source provides sufficient quantities for most production requirements, and as a residue is available for the lowest possible cost.

3) *Nonwoven products, including insulation, from bast fibres offer the global potential totaling US $ 4 - 12 billion in annual sales*

   With strong levels of capitalization, market and technical developments very large markets for bast fiber crops can be carved out from the present array of competing materials.

Nonwoven products, including insulation, offer the global potential for US $ 4 - 12 billion in sales. Fiber reinforcements in thermoplastics could exceed US $ 2 billion. Using proprietary technology building materials markets could reach over US $ 1.0 billion, and at lower margins and extensive substitution for wood (should environmental regulation change significantly) market penetration in building materials could exceed US $ 20 billion.

4) *Smaller and less mature opportunities exist for the core portion*
Additional, probably smaller and less mature, opportunities exist for the core portion from bast fiber crops. Leading non-flax bast fiber crops offer the greater potential for these core markets.

5) *Europe - a clear leader in technical development*
In terms of product development Europe is a clear leader in technical development. Asia, namely the region from India to China has probably the greatest market penetration of bast fibers, along with similar strong, stiff natural fibers including abaca, sisal, and coir. Technologies in these areas tend to be less technically refined and sophisticated. South America, Africa, and Oceania presently have small levels of both production and product and market development. North America should try to learn as much as possible from Europe, particularly in terms of technical matters. North America in the mid-term is more strongly positioned to utilize its lower land costs (as compared to Europe), greater economies of scale, and stronger entrepreneurial and market development drive to establish larger successful bast production facilities. In the longer term, this bast fiber processing and development model may be transferred to tropical and subtropical growing areas in developing regions.

6) *A critical threshold must be overcome to obtain success*
A substantial, notable threshold exists which any processors must contend with and overcome in order to be successful in bast stalk processing. This threshold requires any processor must possess a substantially high level of expertise and resources in marketing, financial resources, and technical expertise. Ultimately one must find markets for the bast fiber product. At this time, market research leads BioComposite Solutions to believe that only automotive producers have a significant interest in natural fibers to place substantial orders, beside the more traditional specialty pulp markets. Within the automotive sector the approval process generally requires approximately 12-30 months from the time of first contact to the time in which product can be shipping for a substantial industrial order.

7) *In nearly all non-automotive markets, bast processors must convince customers that bast or core fibre offers competitive value.*
In virtually all other areas one must convince the party who will buy the bast fiber product of it competitive value. For those processors selling a basic or enhanced fiber product, it can be shown rather easily that bast fiber offer a greater value than glass fibers or other fillers.

8) *Processing equipment and parameters must often be modified*
Nevertheless, processing equipment and parameters must be modified to accept the lower density fiber having different blending, resin compatibility, and processing machinery wear characteristics than convention materials. This example illustrates the magnitude of change which processing must be willing to accept in order to incorporate natural fibers into the processing operations.

11.3 CONCLUSIONS:

Saskatchewan holds a unique and advantageous position to attract suitable processors to utilize and process oilseed flax residue into value-added products. Fundamentally, if the proper recruitment of the best business and process developers and financial incentives are put in place, virtually all sufficiently large concentrations of linseed stalk residue can be processed into value-added bast fiber products in the Province of Saskatchewan within the next five to eight years. Markets for the shive (core) and dust portion are limited and yield low value, generally ranging from CDN $30 - $180/metric tonne (MT). By contrast, the bast fibre yields CDN $450 - $1,140/MT, with enhance fibre yielding CDN $720 - $1,700/MT. Value-added products incorporating bast fibre can be expected to yield CDN $1,300 - $3,300/MT. The relative wide range of prices illustrates the low degree of development and structure within the overall market. Additionally, the degree of quality and specific market pursued will also play a significant role in determining the value as well. With fundamental and applied research, strong business recruitment for the most helpful technology and business developments enticed by sufficient incentives, the Province of Saskatchewan can realize $200,000,000 to $400,000,000, (CDN) possibly even more, in annual value-added processing and manufacturing from linseed flax in ten years.

For companies considering entering bast fibre processing three core areas of competency are critical.

1) Strong, aggressive market development, necessary to break little-known linseed flax into new markets,
2) Technical competencies, essential in decortication and valuable for fibre enhancement and value-added manufacturing, and finally
3) Financial capitalization strength, for both projected costs as well as sufficient reserves for contingencies that are likely in such pioneering ventures.

Great potential exists, but the bast fiber industry is still struggling, and significant questions remain as to whether the industry can accumulated the necessary human, technological, and capital resources to overcome the initial start-up challenges. Over the last three years—particularly in the development of flax, hemp, and kenaf—enough momentum has gathered that success appears both reasonably likely and imminent.